SPECIFICATION

TITLE OF INVENTION: INTERNALLY RESILIENT TIE FOR RAILROAD TRACK

Inventor: Jan H. Zicha, P.E.

References Cited

U.S. PATENT DOCUMENTS

US-6,364,214 B1	*	6/2000	Sonneville	238/115
US-5,203,501	*	04/1986	Vanotti, Gerard	238/265
US-4,609,144	*	09/1986	Harmsen, John L	238/1
US-4,728,032	*	03/1988	Beigl et al	238/382
US-4,616,395	*	10/1986	Farese et al	29/460
US-6,027,033	*	02/2000	Vanhonacker, Patric	238/382
US-2,719,676	*	10/1955	Prater	238/24
US-814,796	*	03/1906	McCallum	238/17
US-1,214,339	*	01/1917	McCourt	238/91

Jan H. Zicha, Upgrading Track and Roadbed for High Speed Operations, FRA Report DTFR 53 00-P-00377.

FIELD OF INVENTION

The present invention pertains to field of devices for supporting the rails of a railway.

BACKGROUND OF THE INVENTION

Significant and frequently critical part of track loading scenario is the reaction of the track to complex dynamic forces that reflect dynamic excitation of the vehicle that is generated by random irregularities of the track geometry and by variations of track stiffness. However, the conventional track design methods address these issues by time-independent static design approaches only. As a result, analyses of dynamic track/train interaction systems that capture interdependence of track and train components illustrated in Fig. 6 are not usually provided. In reality, dynamic forces from vehicles are not equal to the static reaction of the track as it is typically assumed by the contemporary state of the art in the track design field. The devices invented by Mc Court, H.L.Prater, Harmsen, Vanotti, Beigl, Pratter, Vanhonacker, Farese, and Mc Callum provide constant static resiliency within the ties or on the ties. However, they do not address the actual dynamic response of track structure within the relevant dynamic track/train interaction system. In particular, these and similar devices lack dynamic dampening as the single and most critical dynamic track performance parameter directly related to the longevity of the track structure. Consequently, performance of these systems is incidental in spite of the resiliency they offer. In most of these and similar cases, intense correctional maintenance is necessary so that instances of significant acceptance in railway practice are rare. Only the Sonneville's LVT ballastless track system is dynamically designed and provides extraordinary dampening. Its installations in Euro-tunnel between France and United Kingdom, and on fourteen rapid transit and railroad track systems worldwide provide unprecedented reduction of track maintenance. However, the Sonneville's LVT system is restricted to ballastless track and used exclusively where concrete tunnel inverts and bridge slabs exist to provide firm structural foundation. This restriction simplifies the dynamic track/train interaction system, eliminates variability of subgrade and foundation soils indicated in Fig. 6 and leads to a specific product

named Low Vibration Track (LVT) produced by Permanent Way Corporation and Sonneville International Corporation. Sonneville excludes utilization of LVT system in ballasted track because the potential dynamic instabilities of foundation soils and their variability along the railway line lead to entirely different dynamic loading patterns. The invention of Internally Resilient Tie expands the application of the damper-like arrangement of independent block masses, proven by the Sonneville's LVT system on ballastless track, to the ballasted track category. This is facilitated by further development of the dynamic track/train interaction analyses and specialized software for solving the system shown in Fig. 6 demonstrated in its predecessor form in the referred FRA report DTFR 53 00-P-00377, Jan H. Zicha, Upgrading Track and Roadbed for High Speed Operations, January 30, 2001, and by advanced geotechnical exploration of foundation conditions of the track subgrade in the area of installation Internally Resilent Ties by specialized railway application of remote sensing methods of engineering geophysics.

While the Internally Resilient Ties resemble the devices patented by Mc Court, H.L.Prater, Harmsen, Vanotti, Beigl, Pratter, Vanhonacker, Farese, Mc Callum and Sonneville, they possesses improved properties not sought or expected by prior art. They are better suited to resist actual dynamic loading forces acting in a ballasted track exposed to high speed and heavy axle load operational environments.

Particularly unsuccessful were attempts of prior art to reduce overall track stiffness by the increase of resiliency of the rail pad elastomer located directly under the rail. The rail pad is destroyed quickly by dynamic forces corresponding to high frequency vibrations if made sufficiently soft to be effectual in the reduction of the overall track stiffness. For this reason, hard rail pads must be used. The nominal stiffness of a ballasted track equipped with standard

Significant and frequently critical part of track loading scenario is the reaction of the track to complex dynamic forces that reflect dynamic excitation of the vehicle that is generated by random irregularities of the track geometry and by variations of track stiffness. However, the conventional track design methods address these issues by time-independent static design approaches only. As a result, analyses of dynamic track/train interaction systems that capture interdependence of track and train components illustrated in Fig. 6 are not usually provided. In reality, dynamic forces from vehicles are not equal to the static reaction of the track as it is typically assumed by the contemporary state of the art in the track design field. The devices invented by Mc Court, H.L.Prater, Harmsen, Vanotti, Beigl, Pratter, Vanhonacker, Farese, and Mc Callum provide constant static resiliency within the ties or on the ties. However, they do not address the actual dynamic response of track structure within the relevant dynamic track/train interaction system. In particular, these and similar devices lack dynamic dampening as the single and most critical dynamic track performance parameter directly related to the longevity of the track structure. Consequently, performance of these systems is incidental in spite of the resiliency they offer. In most of these and similar cases, intense correctional maintenance is necessary so that instances of significant acceptance in railway practice are rare. Only the Sonneville's LVT ballastless track system is dynamically designed and provides extraordinary dampening. Its installations in Euro-tunnel between France and United Kingdom, and on fourteen rapid transit and railroad track systems worldwide provide unprecedented reduction of track maintenance. However, the Sonneville's LVT system is restricted to ballastless track and used exclusively where concrete tunnel inverts and bridge slabs exist to provide firm structural foundation. This restriction simplifies the dynamic track/train interaction system, eliminates variability of subgrade and foundation soils indicated in Fig. 6 and leads to a specific product

concrete cross ties is then usually higher than what corresponds to the results of theoretical analyses and to empirical findings. The problem is particularly apparent on bridges and tunnel inverts with ballasted decks where the deterioration of track geometry is particularly intense. Internally Resilient Ties offer sufficient reduction of the nominal track stiffness without compromising hardness of rail pads.

All prior art concrete ties are lifted during the upward deflection of the rail that occurs at a certain distance from applied vertical wheel load. This movement is a major contributor to the deterioration of track geometry. Wooden ties with properly installed conventional cut spikes used to secure rail in its position on the tie do not rise because a small space corresponding to the upward deflection of the rail is left between the bottom contact surface of the cut spike's overhang and the upper contact surface of the rail's foot. This feature facilitates the desired upward movement of the rail without lifting the tie off its contact plane with ballast called rail float. Internally resilient ties permit such a movement so that the rail float is no longer restricted to wood ties with cut spikes.

The spread of stray currents and decrease of electrical resistance that is needed for maintaining electrical track circuits appear on any track during rainy weather. Stray currents constitute major liability problems along electrified railway lines due to deterioration of neighboring utilities. While the insulators of track fastening devices are rigorously tested, the leakage occurs mostly through the water layer, dust and steel filings present on the surface of track components. This is because rail support assemblies of prior art do not involve insulators that would create dry areas under their overhangs as it is the case in suspending power distribution lines. Internally Resilient Ties involve and overhang that creates dry area to interrupt the surface water layer.

Relatively light use of steel ties is attributed to their actual or perceived inadequate electrical insulation characteristics. The enhanced electrical insulation properties of Internally Resilient Ties may contribute to increased utilization of steel ties in the future.

The ballastless track systems that involve large blocks enclosed in rubber boots under the rails, such as the referred LVT system by Sonneville, facilitate large consumption of kinetic energy before it reaches the main vibration-abating insulator. However, the prior art blocks and additional components placed in ties of ballasted track are too light and small to offer comparable enhancement of vibration abatement. The vibrations radiating from heavily traveled lines equipped with ballasted track constitute major environmental problems in large cities regardless of the type of rail support used. The masses of independent blocks used in the Internally Resilient Ties are sufficient to result in the desired reduction of environmentally objectionable vibration spread.

ABSTRACT

The main body of the Internally Resilient Tie, the tie case (1), includes two recesses to receive two independent blocks (2), enclosed in rubber boots (4), equipped with standard rail fasteners (7) and protected with hard standard rail pads (5), one block (2) under each rail (3). The bottom elastomer (6) is located inside the boot under the block. In a sequence of Internally Resilient Ties, the masses of the blocks (2) and the spring rates of bottom elastomers (6) can vary. Block retainer assemblies, consisting of components (8) thru (16), keep the blocks in the tie case (1) when the Internally Resilient Tie is lifted by rails while allowing small movement of the blocks upward. A non-metallic insulating collar (12), overhanging the edge of the block and sloping down, is placed around the upper perimeter of each block.

BRIEF SUMMARY OF THE INVENTION

Installation of Internally Resilient Ties in a ballasted track facilitates optimization of the dynamic track/train interaction regime according to a model illustrated on Fig. 6 to reduce track maintenance and to allow speed increases without costly deep soil replacements that are conventionally performed to remove naturally occurring variations of the track foundation. Unless the soils are exceptionally weak, this optimization is achieved by varying the spring rate of the bottom elastomer (6), by varying the mass of the independent block (2), and by choosing dimensions and materials of the assembly to provide high dynamic dampening.

One independent block (2) is placed under each rail (3) in a recess inside the tie case (1). The rail is attached to the independent block (2) by a threadless standard conventional fastener (7). The rail (3) is seated on a standard conventional elastomeric rail pad so that the mass of the block (2) is placed between two elastomers what results in its dynamic damper action. Dynamic forces corresponding to high frequency vibrations are abated by a standard rail pad of sufficient and constant hardness while the stiffness variations and nominal track stiffness adjustment of the assembly are performed at the elastomeric bottom pad (6) under the block in the context of the broader dynamic track/train interaction control. This feature has a potential of optimizing nominal stiffness of a track equipped with concrete ties and eliminating the increased track maintenance intensity experienced on continuously ballasted bridges and tunnel inverts.

The independent block (2) is prevented from being pulled out of the tie case (1) by block retainer assemblies (8 through 16) when the Internally Resilient Tie is lifted by rail (3) during track installation and maintenance. However, a small movement and elastic restrain are provided to facilitate rail float so that the intensity of track maintenance is reduced. The releasing and

retaining portion of the block retainer is thread-less to eliminate maintenance-intensive loosening of corroded threaded components.

A non-metalic collar (12) is attached on the top of the block (2) to provide a dry area under its overhang. Surface leakage of stray electric currents is thus interrupted.

Large enough masses of independent blocks (2) are used to facilitate absorption of significant portion of kinetic energy of environmental vibrations before the bottom elastomeric pad (6) is mobilized so that unprecedented levels of vibration insulation of ballasted track are available to solve relevant environmental way-side problems in populated areas.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 includes elevation, crossection and plan view of Internally Resilient Tie with Independent Booted Blocks and Concrete Case constructed in accordance with the present intention and for use on ballasted track.

Fig. 2 includes elevation, crossection and plan view of Internally Resilient Tie with Independent Booted Blocks and Steel Case constructed in accordance with the present intention and for use on ballasted track.

Fig. 3 includes Detail of Section I-I and block retainer assemblies cast in a concrete tie case.

Fig. 4 includes Detail of Section II-II and block retainer assemblies installed on a steel tie case.

Fig. 5 includes plan view relevant to block retainer assemblies.

Fig. 6 includes Dynamic Track/Train Interaction System – Model for One Axle

DETAILED DESCRIPTION OF THE INVENTION

The internally resilient tie is based on application of specialized design process of advanced dynamic track/train interaction analysis demonstrated in the enclosed report Upgrading Track and Roadbed for High Speed Operations by Jan H. Zicha, DTFR 53-00-P-00377, dated January 30, 2001. This process facilitates an expansion of the advantages of added controlled sprung masses of independent blocks to ballasted track. These advantages have been already demonstrated in the category of ballastless track types with independent booted blocks, such as Sonneville's LVT system that are exposed to different loadings due to the presence of firm structural foundations. While the appearance of internally resilient tie is similar to prior art, it serves different function and the actual conditions of the track foundation and the nature of ballasted track are reflected in a different process of design, analyses and installation of sequentially installed internally resilient ties. Wherever foundation conditions vary, the unprecedented variations of spring rates of the bottom elastomeric pad (6) and variations of the masses of the blocks (2) are necessary to bring about advantages described in the Background of Invention and Brief Description of the Invention.

Large components of the internally resilient tie have been described in the Abstract and Brief Description of the Invention and are apparent from enclosed Figures 1 and 2.

Block retainer (8) is attached to the concrete tie case (1) by its anchoring protrusion cast into the concrete of the tie case (1) shown on Fig. 1. Block retainer (16) is attached by a bolted steel to steel connection to the steel tie case (1) shown on Fig. 2. Except for this connection, the block retainer is thread-less. Flat leaf springs (9) and (10) are inserted into a curved slot in a metallic insert (8) and (16). During installation, the lower leaf spring (9) is inserted first. Then the upper leaf (10) is driven in. It deflects and causes the leaf (9) to deflect as well. The leaves

(9) and (10) stay within the slot by thus introduced pre-load. An eventual shifting of the leaves that would loosen the plates is prevented by the pin (11) inserted into the aligned holes in the leaves (9) and (10) and in shoulders (8) and (16). The contact surface on the block's top (2) can be lowered or raised by inserting member (14) of an adjusted depth into the slot created by two members (15).

CLAIMS

1. Internally resilient tie for ballasted railway track consisting of two separate independent blocks enclosed in rubber boots, supported by bottom elastomeric pads, inserted into recesses in a concrete tie case, equipped with elastic rail fastenings including elastomeric rail pads of standard stiffness on their top surfaces, made of materials of such densities and dimensions that their masses can vary so that in combination with the bottom elastomeric pads of variable stiffness the dynamic track/train interaction of a track equipped with a sequence of internally resilient ties is optimized using specific design process based on a model that captures dynamic representation of the rail vehicle, the track structure and layered elastic half space of track foundation as one integrated system; while the naturally occurring irregularities and variations of the track's foundation materials supporting sequences of internally resilient ties are compensated for by installation and maintenance processes which vary masses of the blocks and spring rates of bottom elastomers according to the geological and geotechnical structure of track foundation.

2. Internally resilient tie for ballasted railway track consisting of two separate independent blocks enclosed in rubber boots, supported by bottom elastomeric pads, inserted into recesses in a steel tie case, equipped with elastic rail fastenings including elastomeric rail pads of

standard stiffness on their top surfaces, made of materials of such densities and dimensions that their masses can vary so that in combination with the bottom elastomeric pads of variable stiffness the dynamic track/train interaction of a track equipped with a sequence of internally resilient ties is optimized using specific design process based on a model that captures dynamic representation of the rail vehicle, the track structure and layered elastic half space of track foundation as one integrated system; while the naturally occurring irregularities and variations of the track's foundation materials supporting sequences of internally resilient ties are compensated for by the installation and maintenance processes which vary masses of the blocks and spring rates of bottom elastomers according to the geological and geotechnical structure of track foundation.

3. An internally resilient railroad tie apparatus equipped with block retainers in concrete railroad tie cases so as to hold blocks including a boot with an elastomeric pad positioned at the bottom of said boot which are received in the tie cases for supporting rails forming complete rail tie assemblies, said apparatus comprising: a device for retaining the blocks in the tie apparatus such that said rail tie assemblies may be lifted and moved by rail during track installation and maintenance, and for releasing the blocks from the ties when the elastomeric pad or the boot has to be replaced or removed.

4. An internally resilient railroad tie apparatus equipped with block retainers in steel railroad tie cases so as to hold blocks including a boot with an elastomeric pad positioned at the bottom of said boot which are received in the tie cases for supporting rails forming complete rail tie assemblies, said apparatus comprising: a device for retaining the blocks in the tie apparatus such that said rail tie assemblies may be lifted and moved by rail during track installation and

maintenance, and for releasing the blocks from the ties when the elastomeric pad or the boot has to be replaced or removed.

5. The internally resilient railroad tie of claim 3 wherein the block retainers comprise a cast iron insert equipped with an anchor member for anchorage in the concrete tie case, and with a curved slot at the top of the anchor member to receive leaf springs that are secured by a vertical pin inserted into aligned holes on top of the anchor member.

6. The internally resilient railroad tie of claim 4 wherein said block retainers comprise a cast iron insert equipped with an anchor having a thread extension for attachment to a steel case, said anchor member having a curved slot at the top to receive leaf springs that are secured by a vertical pin inserted into aligned holes on top of the anchor member.

7. The internally resilient railroad tie of claim 5 wherein a space is left between the bottom surface of the bottom leaf spring and the corresponding contact surface of the block so that the upward movement of the rail occurring at a certain distance from applied wheel load is facilitated without lifting the concrete tie case of the internally resilient railroad tie and without any other interference with its contact plane on ballast.

8. The internally resilient railroad tie of claim 6 wherein a space is left between the bottom surface of the bottom leaf spring and the corresponding contact surface of the block so that the upward movement of the rail occurring at a certain distance from applied wheel load is facilitated without lifting the steel tie case of the internally resilient railroad tie and without any other interference with its contact plane on ballast.

9. Block of internally resilient tie of claims 3, and 4 comprising a sleeve made of electrically insulating material attached to the top of the block in such a manner that an overhang

standard stiffness on their top surfaces, made of materials of such densities and dimensions that their masses can vary so that in combination with the bottom elastomeric pads of variable stiffness the dynamic track/train interaction of a track equipped with a sequence of internally resilient ties is optimized using specific design process based on a model that captures dynamic representation of the rail vehicle, the track structure and layered elastic half space of track foundation as one integrated system; while the naturally occurring irregularities and variations of the track's foundation materials supporting sequences of internally resilient ties are compensated for by the installation and maintenance processes which vary masses of the blocks and spring rates of bottom elastomers according to the geological and geotechnical structure of track foundation.

3. An internally resilient railroad tie apparatus equipped with block retainers in concrete railroad tie cases so as to hold blocks including a boot with an elastomeric pad positioned at the bottom of said boot which are received in the tie cases for supporting rails forming complete rail tie assemblies, said apparatus comprising: a device for retaining the blocks in the tie apparatus such that said rail tie assemblies may be lifted and moved by rail during track installation and maintenance, and for releasing the blocks from the ties when the elastomeric pad or the boot has to be replaced or removed.

4. An internally resilient railroad tie apparatus equipped with block retainers in steel railroad tie cases so as to hold blocks including a boot with an elastomeric pad positioned at the bottom of said boot which are received in the tie cases for supporting rails forming complete rail tie assemblies, said apparatus comprising: a device for retaining the blocks in the tie apparatus such that said rail tie assemblies may be lifted and moved by rail during track installation and